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Similarities and Differences in Learning of Metacognitive Skills:
Computer Games Versus Mathematics Education

Su Ting Yong, The University of Nottingham, Semenyih, Malaysia
Peter Gates, The University of Nottingham, Nottingham, UK
Andy Tak-Yee Chan, The University of Nottingham, Semenyih, Malaysia
https://orcid.org/0000-0003-2267-4949

ABSTRACT

This article explores the potential use metacognitive skills learned in computer games to teach mathematics. This study explored the similarities and differences in the learning of metacognitive skills between computer games and mathematics education. A mixed-methods approach was employed in which a quantitative survey (students, n=174) and a qualitative interview (six mathematics teachers, eight students) were administered to concurrently at two secondary schools in Malaysia. Data collected has shown that there is no direct and explicit connection between the two learning contexts. In computer games, pupils could learn: (a) multitasking, (b) land navigation, (c) teamwork, (d) bottom-up approach to problem solving, and (e) concentration skills. However, it is understandable that a mathematics education (a) is single-tasking, e.g. solves problems step-by-step, (b) uses graphic representation, (c) involves collaborative learning, (d) follows top-down approach to problem-solving, and (e) could use multiple sensory modalities to ameliorate learning.

KEYWORDS

Computer Games, Concentration, Land Navigation, Mathematics, Metacognitive Skills, Multitasking, Problem-Solving, Teamwork

INTRODUCTION

Modern computer games are becoming more advanced and sophisticated. The games require not only physical skills but also strong metacognitive skills, flexibility and adaptability. “Modern video games have evolved into sophisticated experiences that instantiate many principles known by psychologists, neuroscientists, and educators to be fundamental to altering behaviour, producing learning, and promoting brain plasticity” (Green & Seitz, 2015, p. 102). The evolution of computer games has changed the mental abilities needed to play the games. Apparently, gamers have sophisticated knowledge and thinking skills.

Similarly, solving mathematics problems requires sophisticated and strong mental abilities to think critically, logically, and creatively. Mathematics problem-solving is not simply the application of formula and model answer. It requires associated thinking, strategies and motivation. Problem-solving plays a significant role in mathematics education since it requires a proper understanding and manipulation of various complex thinking skills. There are a few approaches to mathematics

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problem-solving and all the approaches are fundamentally built on the four-stage model of Polya (1945). Other than the four-stage model, non-routine problem-solving requires higher-order thinking and metacognitive skills.

The purpose of this study was to explore the similarities and differences in learning of metacognitive skills between computer games and mathematics education. Firstly, the authors identified the key metacognitive skills learned in computer games. Then, the metacognitive skills were analyzed from the context of mathematics education. Finally, a mathematics pedagogy was proposed in the conclusion.

LITERATURE REVIEW

Metacognition

Metacognition is the second-level mental operation. Metacognitive is defined as "knowledge and cognition about cognitive phenomena" (Flavell, 1979, p. 906). Following the original definition given by Flavell (1979), multiple definitions are given in the literature. An overview of these definitions clearly demonstrates that metacognitive is the awareness of one's thinking, and assessment of one's own ability to think and control one's cognitive processes. Metacognition is thinking about thinking. Metacognitive skill is one of the metacognitive components. Metacognitive skill is knowing what one can do (Biryukov, 2004) or "knowledge of when to use, how to coordinate, and how to monitor various skills in problem-solving" (Mayer, 1998, p. 53). Metacognitive skill includes a control aspect of learning (Kleitman & Stankov, 2007) and regulation of cognition (Ozsoy & Ataman, 2009). The regulation of cognition involves: (1) planning and prediction: selection of appropriate strategies and allocation of cognitive resources before the task; (2) monitoring: awareness of one's understanding and performance during the task; (3) evaluating: appraising the performance and efficiency after task completion (Ozsoy & Ataman, 2009; Schraw, 1998). Metacognitive skill enables a problem solver to analyze the problem, select an appropriate strategy to address the problem from an array of possible alternatives, and monitor the problem-solving process to ensure that it is carried out correctly.

Metacognition in Mathematics Learning

Mastering each component of cognitive skill is not sufficient to promote non-routine mathematical problem-solving because the problem solver needs to know when and how to apply specific learning strategies and monitors these cognitive processes (Mayer, 1998). Efficient use of the cognitive content is possible only through metacognitive skills (Mayer, 1998; Ozsoy & Ataman, 2009; Yimer & Ellerton, 2006). Problem solvers may master the basic cognitive skills, but fail to apply what they have learned to a new situation as they may not have the ability to organize and control the basic skills in solving a higher-level task (Mayer, 1998). A learner with poor metacognitive skills is not able to provide accurate monitoring, reflection, evaluation, and adjustment of effective learning (Yimer & Ellerton, 2006). Failure in metacognitive skills may lead to failure in mathematical thinking and problem-solving. Cognitive and metacognitive strategies work well together in attaining the solution of mathematical problems.

Metacognition in Computer Games

During the early development of video games in the 1980s, the gameplay mainly focused on the speed and capability to operate the game controllers and not much in the way of mental abilities were involved. Nowadays, a children's game like *Pokemon GO* involves land navigation skill, spatial ability, vocabulary, and thinking skills. In addition, metacognitive skills can be developed or improved by playing different types of computer games. The metacognitive skill learned in a strategy genre is problem-solving (Cherenkova & Alexandrov, 2013) because strategy games involve planning, decision-making, and execution and adjustment of actions (Martinovic et al., 2014). Games within a simulation